Lesson 3

ADCIRC Conceptual Model

3.1 Introduction

This lesson will teach you how to build a conceptual model in the *Map* module of *SMS* and convert that model into a mesh (grid) for analysis inr *ADCIRC*. You will start by reading in a coastline and a bathymetry file.

The data used for this tutorial is from Shinnecock inlet and the surrounding coastline in the state of New York.

3.2 Creating the Model Coastline

The first thing we want to define is the extents of the model domain. This will become the boundary of our computational mesh. The domain is defined by the coastline around our area of interest as well as an enclosing polygon in the ocean. We can use a coastline extracted from a database, as we did in Lesson 2, but these coastlines tend to be too detailed. This is especially true when we get away from our main area of interest. Our main area of interest is around Shinnecock inlet.

We can create the coastline boundary from the extracted coastline. To start this process:

1. Open the file, "east_coastline.map". This is the boundary from Lesson 2, saved in an *SMS* "map" file for faster access. In this file, the coastline and islands consist of 457 individual arcs. These arcs contain many bends and twists along the coastline that would require very high resolution to preserve.

This level of resolution would slow down analysis, but not result in a more accurate answer.

2. Select *Feature Objects* | *Clean*. “Cleaning” a set of feature objects is the simplest way to make sure errors have not been made while creating those features. Examples of errors include very short arcs dangling from a coastline, two arcs that cross each other, but do not intersect, or two nodes that are very close together, but should be a single node.

3. Turn off the check for Intersecting arcs. This was performed when you read in the coastline file (in Lesson 2).

4. Turn on *Snap nodes* and *Remove dangling arcs.* Set the *Tolerance* and the *Minimum length* to 0.1. This will cause nodes within 0.1 meters of each other to be merged and any arc with a free end that is shorter than 0.1 meters will be deleted.

5. Click *OK* and SMS will perform the cleaning operation.

Now we want to merge the coastline along the mainland into a single arc. To do this:

1. Select the *Select Node* tool .

2. Select *Edit* | *Select all.*

3. Select *Feature Objects* | *Vertices <-> Nodes.* This converts all nodes that simply join two arcs into a vertex (merging those two arcs).

Now the 457 arcs have been merged into 366, but the mainland is still not a single arc. This is because of small loops in the coastline. Since it is impossible for a loop to exist in the coastline, these loops are an error. They exist either because of problems in the extraction, or numerical round off errors when intersecting or cleaning the arcs. To finish converting the coastline to a single arc:

1. Select the *Select Arc* tool .

2. Click on the south western end of the coastline. The arc will be selected and you will be able to see where the selected arc ends just to west of Long Island.

3. Zoom into that area and you will see a small loop in the coastline. Select that loop and click the *Delete* macro .

4. Now select the node that the arc used to be connected to, and select *Feature Objects* | *Vertices <-> Nodes.*

5. Repeat steps 1 – 6 one more time and the coastline will be a continuous arc.

Now we want to remove unneeded detail in the coastline. To do this, we must manually edit the arcs. Some small islands should be removed entirely. Small bays or harbors in the coastline that are not of interest will be eliminated. These details don't affect the circulation in the area of interest. To illustrate this process:

1. Zoom in to the southernmost end of the coastline as shown in Figure 3-1.

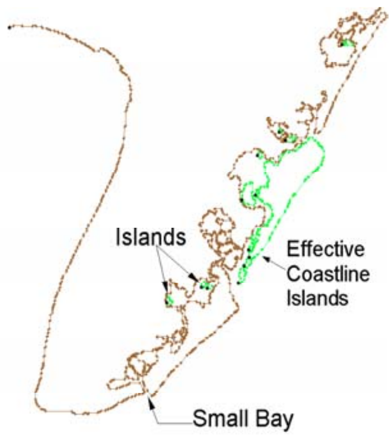


Figure 3-1Southern end of coastline with unneeded details.

2. Switch to the *Create Arc* tool . Create an arc across the mouth of the bay.
3. Switch to the *Select Arc* tool . Select the arc defining the bay & delete it.
4. Switch to the *Select Node* tool , select the two new nodes on the coastline and convert them to vertices merging the coastline arc.

North of the section of coastline you have been editing, several islands form the effective ocean coastline (islands are colored green in the *ADCIRC* interface, mainland is brown). Try connecting these into the coastline and deleting the details until the coastline looks like Figure 3-2.

Figure 3-2 Simplified coastline.

3.2.1 Creating a Simplified Coastline

We could continue to clean up and simplify the coastline as we started in the previous section. However, for a coastline as complicated as the one we extracted around Long Island, this process could take quite a while. Another approach is to use the extracted coastline as a guide, and create a new coastline interactively. To do this:

1. Select *Feature Objects | Coverages.* This will bring up the coverages dialog.

2. Click on the *New Coverage*  macro to create a coverage.

3. Set the coverage type to ADCIRC and enter a name of "Shin Conceptual 1".

4. Click *OK* to exit the dialog. The arcs you read in before will still be displayed, but they will be a grayish blue color. This indicates they are not part of the active coverage.

5. Zoom into the southern end of the coastline as shown in Figure 3-3.

6. Switch to the *Create Arc* tool  and start clicking out a simplified coastline as shown in Figure 3-3.

Figure 3-3Digitizing simplified coastline over top of complex coastline.

In order to speed up this lesson, and to keep everything consistent, we have provided you with a simplified coastline. To read it in now:

1. Delete the current coastline data. Select *File | Delete All.*

2. Open the file, "shin_coastline.map".

3.2.2 Setting the Coordinates

The coordinates of the map file we just read in are State Plane meters. We need to define the current coordinates in SMS so we can perform coordinate conversions later on. To define the current coordinates:

1. Select *Edit | Current Coordinates*.

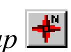
2. Select State Plane NAD 83 (US) for the *Horizontal System*.

3. Select New York Long Island – 3104 for the *St. Plane Zone* and Meters for the *Units*.

4. Select Local for the *Vertical System* and Meters for the *Units*.

3.3 Defining the Domain

We will now define the domain of the region to be modeled. To do this:

1. Make sure you are in the *Map*  module.

2. Choose the *Select Feature Arc*  tool and click on the coastline arc to select it.

3. Choose *Feature Objects | Attributes*.

4. Make sure the *Boundary Type* is set to *Mainland* and click OK.

5. Choose *Feature Objects | Define Domain*.

6. Select the *Semi-circular* option and push OK.

A semi-circular arc is created to define the ocean edge of the domain. *ADCIRC* does not require any specific boundary shape. This semi-circle will actually be distorted when it is run through *ADCIRC*, because it will be run in geographic coordinates. You could create an arc to define the offshore edge of the domain manually if you wish, the define domain command just gives a quick way to define an arc.

3.3.1 Assigning Boundary Types

Boundary types for the initial mesh generation are specified in the *Map* module by setting attributes to Feature Arcs. To set the boundary types:

1. Choose the *Select Feature Arc*  tool from the *Toolbox*.

2. Double click the newly created semi-circular arc representing the ocean boundary.

3. In the *ADCIRC Arc Atts* dialog, assign this arc to be of type *Ocean* and push *OK*.

The ocean arc appears blue. Coastline arcs appear brown. Islands should appear green. These settings are controlled in the *Display Attributes* dialog in the *Map* tab by selecting the arcs *Boundary Condition* button.

3.4 Reading in the XYZ File

The project also requires a source of bathymetric data. In Lesson 2, this included multiple sources that had to be merged together. For this lesson, the data is already combined into a single data file. To load this data, open "shin_scatter.xyz".

The *File Import Wizard* dialog will open, allowing you to specify how the data will be read into *SMS*. For *Step 1* of the dialog, the first line in the *File preview* box is the file header. The next line shows the name of each respective column of data. In this case, the file has three data columns. The first column is the *X* Coordinate, the second column is the *Y* Coordinate, and the third column is the *depth/bathymetry*.

- Click the *Next* > button to move on to *Step 2* of the *File Import Wizard*.

The second step of the File Import Wizard allows you to change other specifications as you read in the bathymetryic file.

- Leave the defaults and click the *Next* > button to move on to *Step 3* of the *File Import Wizard*.

The third step of the File Import Wizard allows you to make a coordinate conversion from the data in the file to the current coordinate system already specified in *SMS*. Notice the current coordinate system at the top of the dialog. The data in the file is in State Plane coordinates, so you will not need to make a conversion.

- Click *Finish* to complete the process.

Figure 3-1shows the points read in from the file.

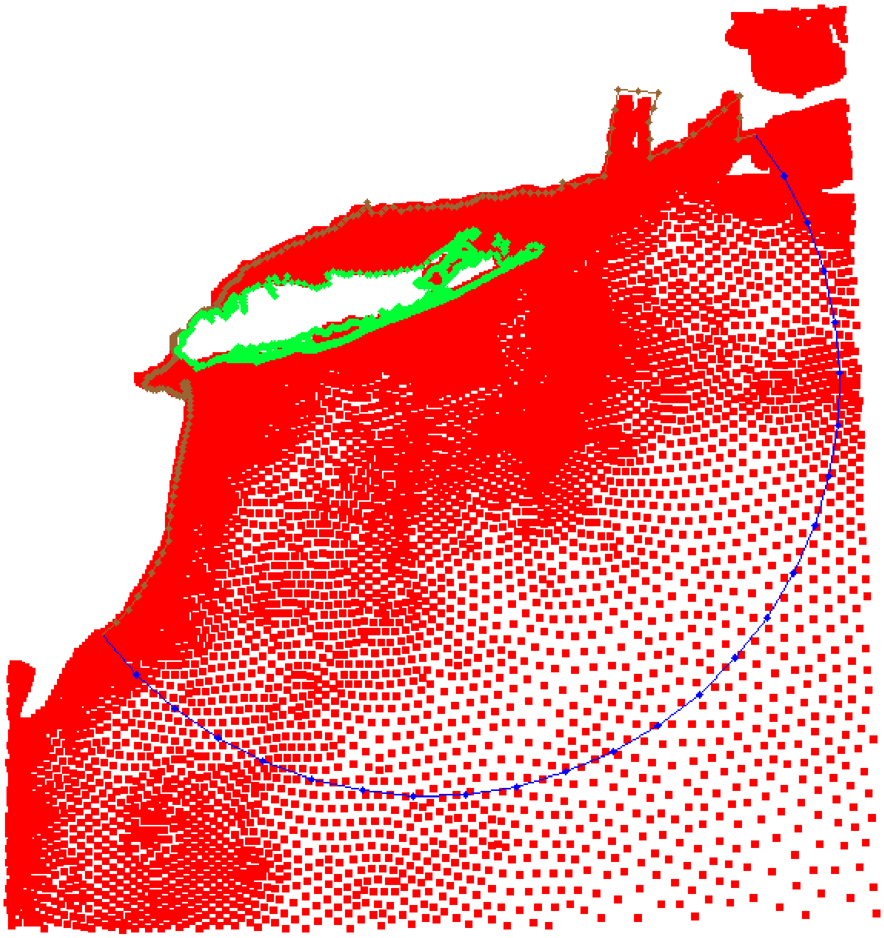


Figure 3-1 Display of shin_scatter.xyz

3.5 Creating A Size Function

Later in this workshop we will use a size function to guide the creation of finite elements inside the domain. In this section, we will create a scatter set and define this size function.

A size function defines a target size for all locations inside the domain. We can create this function by creating a new scatter set whose elevation matches the desired element size. To build a size function, you need to have target element sizes in mind. For this case, we have the following criteria:

- Shinnecock Inlet – approximately 20 m elements.
- Bay behind inlet – approximately 50 m elements.
- Adjacent inlet – approximately 50 m elements.

- Around Long Island – approximately 500 m elements
- Along mainland near Long Island – approximately 5000 m elements
- 10 Km offshore – approximately 5000 m elements
- Deep ocean boundary – approximately 35000 m elements.

To create a size function of this type we start by defining the size for the area of highest interest. To do this:

1. Switch to the *Mesh Module* and select the *Create Mesh Node* tool
2. Zoom into the area of Shinnecock Inlet (Figure 3-4).
3. Create a point at the mouth of the inlet.
4. Change the elevation value of the point to 20 in the edit window.
5. Create a few more points around the inlet.

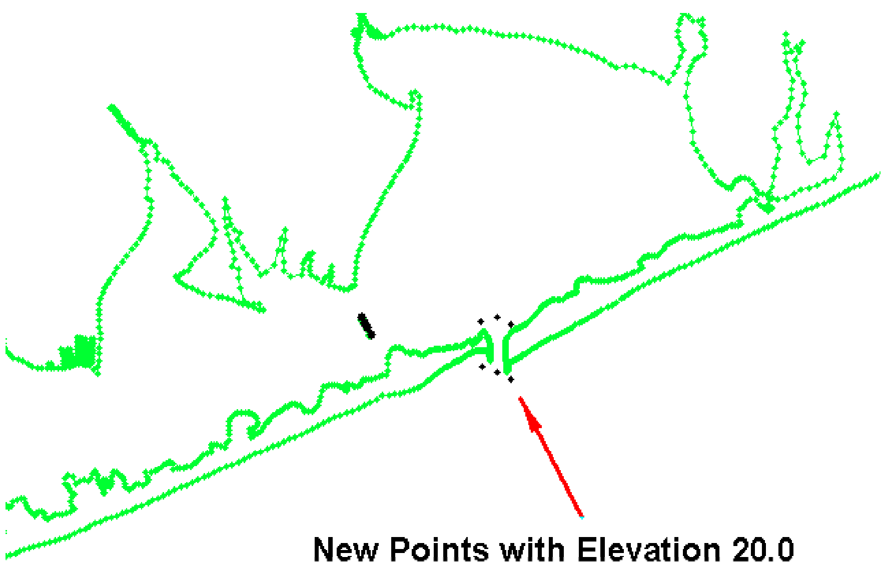


Figure 3-4 Size Function points around inlet.

Next we want to create points with elevation of 50 to define the areas with that size as a target. To do this:

1. Zoom out a little to see the adjacent inlet and the bay behind the inlet.

2. Create a point in the adjacent inlet and change its elevation to 50 in the edit window.

3. Create several other points around the bay. (see Figure 3-5)

Figure 3-5Points defining size of 50 m.

You could follow this process to create additional points across the entire domain. The best size functions vary slowly and continuously. To keep things consistent; you should now read in a file with these points already created. To do this:

1. Change to the *Select Node* tool in the *Mesh Module*.

2. Select *Edit* | *Delete.*

3. Open the file *size.pts*. On the first step of the import wizard, select *mesh* as the type of data to read. This allows you to pick up where you would be if you digitized all the points yourself. When the file was read in, *SMS* triangulates the points so you can examine contours of the size function. Notice how the points cover the entire domain, and how the size (elevation) varies.

What is really needed for the size function is a scatter set. Now that you have the points in *SMS*, convert them to a scatter set by selecting *Data* | *Mesh -> Scatter Set* and entering the name “size pts” for the scatter set name. Now delete the mesh nodes by following steps 1 and 2 above.

You are left with a new scatter set, named “size pts” that defines the desired size of elements everywhere in the domain.

3.6 Creating Polygons

There are many ways in *SMS* to generate a mesh. These include interactive manual methods and automated methods. Since our model of Shinnecock inlet covers a very large area, and will include thousands of elements, we want to use an automatic method for as much of the mesh as possible. However, we still want to be able to control the size and density of the elements that will be created in our mesh. The goal is to create smaller elements in areas where high detail is desired and larger elements elsewhere.

The automated mesh generation methods use various methods to fill in polygonal zones with elements. We will now create these polygons that will be filled for this domain.

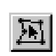
3.6.1 Building Polygons

Normally, it is a good idea to *Clean* your feature objects after they are constructed before you build polygons. This ensures that the zones will be clearly defined. Since we illustrated how to clean earlier, this has already been done for this conceptual model. To create polygons from the arcs on the screen:

- Switch to the *Map*  module and select *Feature Objects* | *Build Polygons*.

3.6.2 Polygon Attributes

We now have a polygon for the ocean area, as well as seventeen polygons which each represent an island. In a conceptual model, each polygon must be selected to assign the proper attributes. The islands are easy to identify since they have green boundaries. However, some of them are very small. To set the attributes for the island polygons.

1. Choose the *Select Feature Polygon*  tool from the *Toolbox* and click inside the largest of the island polygons (the one you can see the background through). When it is selected, the island will be displayed black.

2. Select *Feature Objects* | *Attributes*. (Double-clicking inside the polygon will perform this same step.) The *Polygon Attributes* dialog will open.

3. Select *None* as the *Mesh Type*. This tells *SMS*, that no computations will be performed in this area (because it is dry land), so no elements should be created in this portion of the domain.

4. With the *Mesh Type* set to none, the other attributes are not used, so click *OK* and exit the *Polygon Attributes* dialog.

This method could be repeated another sixteen times to select each polygon individually. However, not only is this tedious, but could be problematic, if you miss and island. To ensure that all island polygons are set with these attributes:

1. Select *Edit | Select All*. At the bottom of the graphics window a message will appear telling you that 18 polygons are selected.

2. Hold down the *Shift* key, and click in the large ocean area. The *Shift* key is used to multiselect. In this case, you deselect the ocean. The message changes to indicate that 17 polygons are now selected. This includes all of the islands.

3. Select *Feature Objects | Attributes* to open the *Polygon Attributes* dialog.

4. The preview window is disabled, because more than one polygon is selected. The *Mesh Type* is also gray, because one of the polygons has already been assigned to be *None*, while the others are still defaulted to *Paving*. The gray combo box indicates that there are multiple settings for the selected entities. Click on the combo box and assign all the polygons to have a *Mesh Type* of *None*.

5. Click *OK.*

3.6.3 Assigning the Meshing Type

Now the islands are set, but we still need to assign attributes for the ocean polygon which is where all the computations will occur. With the *Select Feature Polygon*  tool still selected, double click inside the large ocean polygon. The Polygon Attributes dialog will open.

The *Mesh Type* selection controls what algorithm *SMS* will use to create elements in the polygon. The options and a brief explanation of each are shown in the following table.

Mesh Type	Description
None	No elements generated
Patch	Requires 3 or 4 sided topology. Generates quadrilateral dominated mesh aligned to polygon edges. Most generally applied to riverine situations where elements can easily align to flow.
Adaptive Tesselation	Overlays area with grid. Subdivides each cell of grid based on size of segments of nearest boundaries. Uses the “Area Relax” to move nodes to centroid of their area. In earlier versions of SMS, was the method of choice when dealing with Irregular shaped polygons such as ocean areas. Not recommended now because newer methods are preferred.
Paving	Generates elements along the inner edge of the poygon based on the spacing of segments around the polygon. Requires user to manipulate distribution of elements along arcs to generate desired mesh. Misses interior details. Is a good, fast method for generating elements. Used when no size function available.
Adaptive Density	Same as Adaptive Tesselation, but uses size function to control subdivision of cells. Not recommended since scalar paving generally gives better results.
Scalar Paving	Same as Paving, but uses size function to control offset. Recommended method for ocean polygons if size function available.
Existing Nodes	Allows use of existing nodes if mesh already exists. Not extensively applicable.

To illustrate a few of these methods, you will experiment with the mesh type and use the *Preview* button in the *Polygon Attributes* dialog. For large meshes (up to millions of elements), the process of generating elements can be slow. In some cases it takes hours and is recommended as an overnight or batch type process. For this reason, the *Preview* button is not often employed. In our case, the process takes a few minutes on a 1 GHz machine with 512 MB RAM for each option. If your machine has limited RAM, or is significantly slower than this, you may want to skip the previewing step.

To proceed:

1. In the *Polygon Attributes* dialog, the *Paving* option is defaulted for this polygon. Make sure it is still set to *Paving.*

2. Click the *Preview* button and wait. Several messages describing the progress of the algorithm will be displayed in the status bar and message windows. When finished, you will see a mesh in the preview window that will result form this option. Elements are small along the coastline, where vertices are tightly spaced on the arcs. Elements are larger along the offshore boundary where vertices are further apart. Use the *Pan* and *Zoom* tools in the *Polygon Attributes* dialog to examine the mesh. Zoom into the inlet, and look around the islands.

3. Set the *Mesh Type* to *Adaptive Tessellation* and click the *Preview* button again. Another mesh will appear that was generated based on vertex spacing. The main weakness of adaptive tessellation is the abrupt or discrete jumps in density which show up in the form of darker bands in the element display.

4. Now set the *Mesh Type* to Scalar Paving Density. We won’t preview this option because we’ll see the final mesh later.

5. In the *Mesh Type* section, click the *Scatter Options…* button. This opens the *Scatter Options* dialog.

6. Select the *elevation* function under the *size pts* data set in the data tree. This is the elevation of the size points which we created before as our size function. (Don't get this confused with the elevation of the *shin_scatter* set that is the bathymetric data for the mesh.)

7. Turn on the *Truncate values* toggle in the lower left corner and set a minimum value of 15 and a maximum value of 35000. This tells *SMS* to ignore values in the size function outside of this range. It is useful to prevent areas getting very small sizes that produce extremely large numbers of elements or even worse, negative sizes that could produce an infinite loop.

You now have the mesh type set and are ready to move on.

3.6.4 Assigning the Bathymetry Type

The last polygon attribute we will assign is the bathymetry source. We are using bathymetry from a scatter set. To assign this:

1. In the *Bathymetry Type* section, select *Scatter set* as the click the *Scatter Options…* button.

2. In the *Scatter Options* dialog, choose the *elevation* function in the *shin_scatter* set as the data set.

3. Click the *OK* button twice to get out of both dialogs.

3.7 Creating the Mesh

Once the polygon attributes are set, the mesh can be generated automatically based on the options that were selected. To generate the mesh:

1. Switch to the *Select Feature Point* tool

2. Select *Feature Objects | Map -> 2D Mesh*.

The speed of the meshing process will depend on the speed of your computer. The process could take up to five minutes.

3.7.1 Mesh Display Options

After *SMS* has completed generation of the mesh, you should be able to view the bathymetry, nodes, and elements. To set the display:

Switch to the *Mesh* module.

Select *Display* | *Display Options...* or select the macro from the *Toolbox*.

Turn both the *Nodes* and *Contours* off and the *Elements* on.

Click the *OK* button to close the *Display Options* dialog.

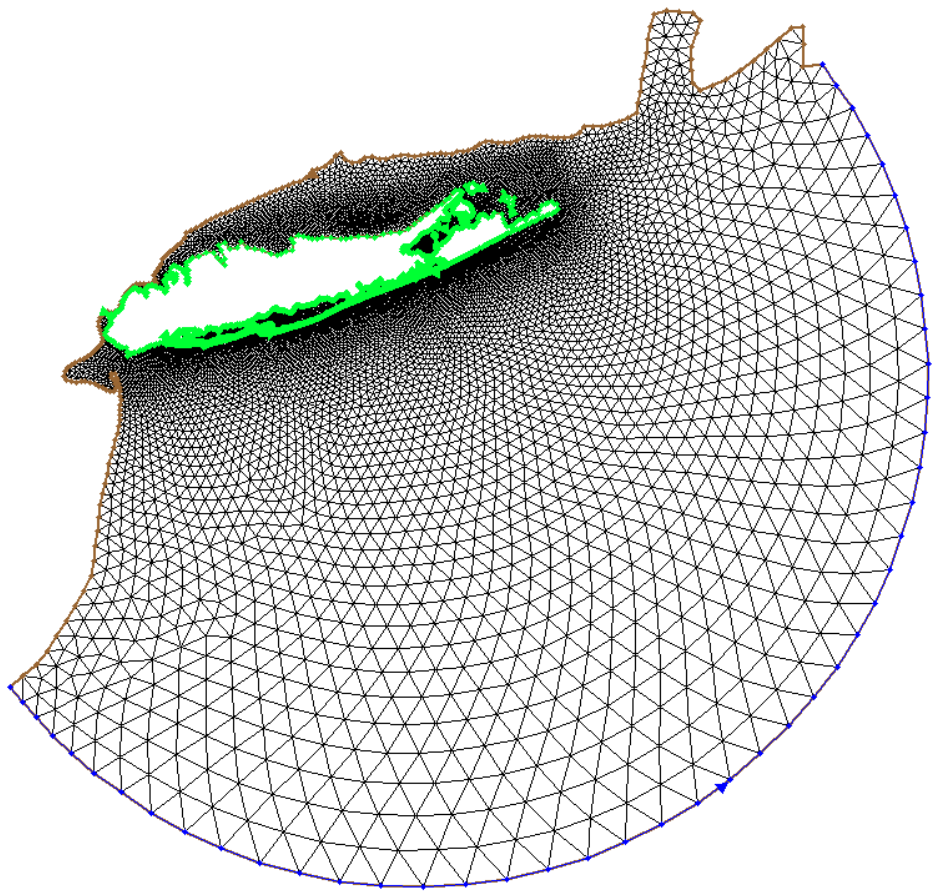


Figure 13-2 View of elements after automatic mesh generation.

Figure 13-2 shows the final mesh. Notice how the elements are smaller closer to the coast and within the inlet.

3.7.2 Coordinate Conversion

The coordinates of the mesh are State Plane coordinate system. This is because it is more intuitive to work in meters when creating a mesh. However, the *ADCIRC* model will expect the coordinates to be in latitude/longitude. To convert the coordinates:

1. In the Convert to section, set the Horizontal System to Geographic NAD 83 (US). Make sure the Units for the Horizontal System are in Meters.

2. Set the Vertical System to Local. Make sure the Units for the Vertical System are in Meters.

3. Click the Convert button to perform the coordinate conversion.

Don't worry that the boundary appears distorted. As you drag the mouse across the graphics window, you can see that the x,y,z coordinates displayed in the edit window are now in lat/lon.

3.8 Conclusion

Once the mesh has been created and refined, final preparations must still be done in order to run *ADCIRC*. The next workshop will guide you through the process of setting up an *ADCIRC* run.